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(54) Printing system.

(57) A method of using a printer system (Fig.1) for identifying one or more different types (41-43) of color objects in a document, selecting a preferred rendering option such as halftoning and/or color matching for each one of such different color object types (41-43), respectively, and then printing the document in accordance with the rendering options selected for each of such different color object types (42-43). In a printing system such as an inkjet color printer (56) coupled through a printer driver (32) to a host computer (44), a default halftoning technique and a default color-matching map are incorporated into the printer system for automatic invocation whenever a particular color object type (41-43) is printed.

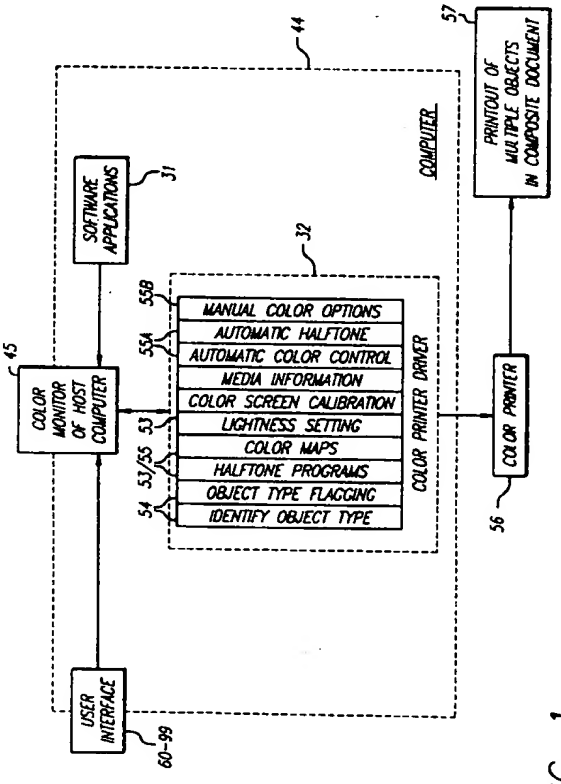

FIG. 1

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This invention relates generally to colour printing, and more specifically to printing different types of colour objects in the same printout.

The following related applications are assigned to the assignee of the present application and are incorporated herein by reference, the European applications listed having the same filing date as this application: European patent application no. (N2986), European patent application no. (N2987), European patent application no. (N2991), European patent application no. (N2990), European patent application no. (N2989), US patent application serial no. 08/188,618, US patent application Serial No. 08/57,244, and US patent application Serial No. 08/60,285.

The use of color monitors for computers has accelerated the need for color printers which can produce a satisfactory printout of what is displayed on the screen. Part of the problem arises from the subjective nature of color. Color is a sensation produced by the combined effects of light, objects and human vision. A particular color or combination of colors may be appealing to one person while at the same time being offensive to another.

Another part of the problem arises from the different color technologies used in computer monitors and color printers. For example, computer monitors are based on a color gamut of red, green and blue pixels (RGB) while color printers such as inkjet printers are typically based on a color gamut of cyan, magenta, yellow and black (CMYK). The RGB color components of computer monitors are combined together in an "additive" way by mixing red, green and blue light rays to form a first variety of different colors, while the CMYK components of color inks are applied to media in different combinations in a "subtractive" way to form a second variety of different colors. A number of different color management techniques have been used on order to provide some form of matching between the colors viewed on a computer monitor and the colors printed by a specific printer using a given ink formula on a particular type of media. Such color management techniques have also employed different types of halftoning in order to improve the color output of printers.

Desktop publishing software programs have created additional problems by allowing different types of objects to be combined together into a composite document, such as photographic images, business graphics (e.g., charts), and scalable text in both color and black. By skewing the printer color output to ensure satisfactory color printing of photographic images, the business graphics in the same document often appear washed out and lose their impact. By skewing the printer color output to ensure satisfactory color printing of saturated vivid colors for business graphics, the photographic image in the same document loses its lifelike appearance.

Some of the aforementioned color printing problems have been partially solved by providing manually controlled printer settings to get the best results available. In addition, sophisticated users who demand exact color matching between screen and printout have obtained some solutions through color management software incorporated in the computer operating system as well as color management software incorporated into third party software applications. Also, some color matching technology has been incorporated into printer drivers which provide the translation interface between a particular computer and/or software application running in the computer and a color printer which acts as a hardcopy output device.

The present invention seeks to provide an improved printing system.

According to an aspect of the present invention, there is provided a method of printing as specified in claim 1.

According to another aspect of the present invention, there is provided a printing system as specified in claim 7.

In a preferred embodiment, there is provided a method of using a printer system to identify one or more different types of color objects in a document, selecting a preferred rendering option such as halftoning and/or color matching for each one of such different color object types, respectively, and then printing the document in accordance with the rendering options selected for each of such different color object types. In its preferred form, all raster data commands are rendered as natural images, all text commands are rendered as text, and all other commands are rendered as business graphics.

In a printing system such as an inkjet color printer coupled through a printer driver to a host computer, a default halftoning technique and a default color matching map may be incorporated into the system for automatic invocation whenever a particular color object is printed.

According to an aspect of the present invention, there is provided a method of color inkjet printing for use in printing color objects of any of a plurality of different object types; said method comprising the steps of providing means for identification and recognition of a plurality of different types of color objects; providing means for using a plurality of different color-rendering options in printing color objects; identifying the type of at least one color object in a document to be printed; selecting a preferred color-rendering option to be used for objects of said identified type; and using a printer system to cause a color inkjet printer to use the preferred color-rendering option of said selecting step to print said at least one color object, of said identified type, in said document.

Preferably, said selecting step includes selecting a halftoning color-rendering option to be used for said identified color-object type.

Advantageously, said selecting step includes selecting a color-matching option to be used for said at least one type of color object.

The selecting step may include selecting both a halftoning color-rendering option and a color-matching option to be used for said identified color-object type.

The identifying step may include identifying the types of color objects which are of at least two different types, in a document to be printed; and said selecting step may include selecting a preferred color-rendering option to be used for each of said at least two different types of color object.

Advantageously, said identifying step includes identifying the types of color objects which are of at least three different types, in a document to be printed; and said selecting step includes selecting a preferred color-rendering option to be used for each of said at least three different color-object types.

Preferably, said identifying step and said selecting step are both accomplished automatically by the printer system recited in said using step.

According to another aspect of the present invention, there is provided a method of printing a composite document having therein color objects of different color-object types; said method including the steps of identifying the type of at least one color object; using a predetermined first rendering option to print all color objects of said one color-object type of said identifying step; and employing a predetermined second rendering option to print color objects of remaining types; different from said one color-object type.

Preferably, said identifying step includes all raster data commands as photo image color objects.

Advantageously, said selecting step includes selecting a preferred halftone color-rendering option to be used for photo image color objects.

The selecting step may include selecting a preferred halftone color-matching color-rendering option to be used for photo image color objects.

The identifying step may include identifying all text commands as text objects.

In an embodiment, said identifying step includes identifying all commands which are not text commands as business graphics color objects.

According to another aspect of the present invention, there is provided a system of printing color documents in a raster printer comprising a printer for applying color to media; a document source for providing specifications for a composite color document having nontext color objects; and a printer system connected through a printer driver to said document source, said printer system including color-management means for providing print-rendering options which are selectively enabled for said nontext color objects.

Preferably, said printer system includes a color inkjet printer.

Advantageously, said color-management means automatically provides default settings for at least one of said print-rendering options.

In an embodiment, said color-management means provides halftone print-rendering options which can be enabled for said nontext color objects.

Preferably, said color-management means provides halftone print-rendering options which can be separately enabled for two different types of nontext color objects.

The color-management means may provide color-matching print-rendering options which can be separately enabled for two different types of nontext color objects.

Additionally, said color-management means may provide haltone print-rendering options which can be separately enabled for said two different types of nontext color objects.

Thus, it is possible by using information about object type to control the rendition to be used in printout, greatly simplifying and reducing the color-management-setting decision-making demands on human operators. That is to say, the operator's work load can be reduced to making halftoning decisions for each object type rather than each object.

This reduction is for each type ordinarily by a factor equal to the number of objects of that type - a number perhaps between one and a thousand, but in a typical or representative desktop-publishing document most commonly may amount to a factor of around five or ten.

It is also possible to improve the performance of a type-to-rendition selection/printing process separately and independently for more than a single object type, which is to say at least two types. Similarly, it is possible to address the enabling of print-rendering options for color objects other than text; it is these objects whose manual management, according to the prior art, particularly challenge and burden the user.

Preferably, the identifying step includes identifying the types of color objects which are of at least three different types, in a document to be printed; and the selecting step includes selecting a preferred color-rendering option to be used for each of the at least three different color-object types.

It is also desirable that the identifying and selecting steps both be accomplished automatically by the prin-

ter system. In another preferred embodiment, however, the selecting step is preferably reserved to the human operator.

We prefer to implement the identifying step by including in that step, as a criterion, identifying of all raster data commands as photo image color objects. In other words, the system preferably interprets presence of a raster data command as characteristic of a photograph or photograph-like color object -- thus avoiding any need for embedment of a separate photo-identification code in the data, or for the operator to identify each photo or the like for the system.

Similarly we prefer that the system in the identifying step identify all text commands as text objects. For instance a command to use a particular font, or justification, or leading, serves as an identifying criterion for text -- again without need for a separate text-identification code or for operator action.

It is also preferred that the identifying step include identifying all commands which are not text or raster-data commands as business graphics color objects. Graphics commands are less standardized or universal in format than those for text and raster data; hence, thus operating by a process of elimination has been found to very effectively identify graphics.

An embodiment of the present invention is described below, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 is a block diagram showing a preferred embodiment of a computer system;

Figs. 2A, 2B, 3A and 3B are a flow chart showing how automatic and manual options in the system of Fig. 1 are used to produce a color printout of a composite document;

Figs. 4 and 5 show a sequence of interactive computer screens generated during the process of Figs. 2A, 2B, 3A and 3B;

FIG. 6 is a schematic block diagram for producing color photo printouts in accordance with the preferred embodiment of FIG. 1;

FIG. 7 is a halftone flow chart for the preferred embodiment of FIG. 1;

FIG. 8 is a color control flow chart for the preferred embodiment of FIG. 1;

FIG. 9 is a functional block diagram showing the relationship of color control and halftoning in processing and printing photographic images;

FIG. 10 is a schematic diagram showing the different color gamuts of visible light, a computer screen, and a printer which are used in the color control flow chart of FIG. 8; and

FIGS. 11 and 12 show a typical color inkjet printer.

Generally speaking, the described embodiment can provide improved print quality for composite documents which have different types of objects to be printed in the same document and in many instances on the same page. In an exemplary printer system as illustrated in the drawings, one or more different types of color objects 41-43 (Fig. 2) are identified and flagged 54 (Fig. 3); a preferred rendering option, such as halftoning, and/or color matching is selected for each one of such different color-object types; and then the document is printed in accordance with the rendering and color-control options selected for each of such different color-object types.

The color inkjet system of the preferred embodiment includes a printer 56 (Figs. 1 and 3) coupled through a printer driver 32 to applications (or operating-system) software 31 running in a host computer 44. A set of default halftoning techniques and default color-matching maps is incorporated in the printer system for automatic invocation whenever objects of respective particular color-object types are to be printed in the absence of user selections.

It is possible to provide either automatic or manual implementation of various color-control and rendering options. For example, in the color inkjet system shown an interactive user interface allows a choice between one-"button" 62 automatic control 53A of color output or multibutton control 63-99 of color output, with both automatic and manual options providing independent control for color halftoning 90 and for color correction 81 based on the types of objects to be printed. The preferred form allows separate print-control options for text 43 , graphics 42 and photo (or photograph-like) images 41

Different print-quality modes 63 in the printer invoke 11, 12 different print-rendering options 21, 22 for a particular object to be printed. In the exemplary embodiment, a printer control 65 automatically invokes an error-diffusion halftoning technique 22 for photo images 41 whenever a high-quality mode 65 is designated, and automatically invokes a dither halftoning technique 21 for photo images 41 whenever a normal 67 or fast 68 print mode is designated.

It is important to note that the location of the color-management functionality is somewhat flexible within the printer system. Such functionality in the presently preferred version of the invention is primarily in the printer driver 32, but it could be implemented in the printer driver and/or printer 56 firmware -- and/or even in the printer 56 hardware (e. g., custom integrated circuits, etc.).

The preferred embodiment is incorporated in an inkjet printer of the type shown in Fig. 11. In particular,

inkjet printer 110 includes an input tray 112 containing sheets of a printing medium 114, which pass through a print zone and are fed past an exit 118 into an output tray 116.

As seen in Figs. 11 and 12, a movable carriage 120 holds print cartridges 122, 124, 126 and 128 -- which in turn respectively hold yellow (Y), magenta (M), cyan (C) and black (K) inks. The front of the carriage has a support bumper 130, which rides along a guide 132; while the back of the carriage has multiple bushings such as 134, which ride along a slide rod 136.

The position of the carriage as it travels back and forth across the medium is determined from an encoder strip 138. This position information is used to selectively fire the various ink nozzles on each print cartridge at the appropriate times during each carriage scan.

Referring next to Figure 1, there is shown in schematic form an embodiment of computer system for producing and printing documents in colour. The system includes a computer 44 provided with a colour monitor 45, a user interface 60-99 of any convenient form, and a colour printer driver 32 operative to drive the printer 56 to produce documents 57 in colour. The computer 31 is driven by appropriate software applications 31.

The printer driver 32 provides in blocks 54 for the identification of the object type of document objects, that is whether they are photographs, drawings or text. Once the object type or types have been identified, the driver flags the objects with their object type at block 54.

At blocks 53/55, the printer driver 32 provides halftone programs, colour maps, setting of lightness, for colour screen calibration and necessary and desired media information. These blocks can provide either automatic colour control and automatic half tone at blocks 55A or manual colour options at lock 55B. Figures 2A, 2B, 3A and 3B show in more detail the preferred process for producing and printing composite colour documents.

Referring first to Figure 2A, the computer 44 is provided with a colour enabled software desktop publishing application which enables a user to generate pages of a document by selecting objects such as text 43 and graphics 42 and to scan into the document photographs 41 and the like. As shown in Figure 2A, the inputted objects can be laid out onto the page, specifying colours for the graphics, in this example a pie-chart 42, and also for the text 43.

As can be seen in Figure 2B, printing of the completed page provides in a menu 61, in this example, three printing options, the first being an automatic option 62 in which the system determines the optimum printer colour mixes on the basis of the object types and printer colours. The second option is a manual colour option 63 in which the user can customise the colour settings so as to achieve desired results. The third option allows the page to be printer in monochrome, using any suitable grey scale.

When the manual colour option 63 is selected, the system provides a manual option menu 80 in which parameters of each object type (text, graphics and photographs in this example) can be adjusted. The adjustable parameters in this example are colour, between three settings, halftone, also between three settings, and lightness.

Operation of the printer driver 32 in the automatic colour mode 62 and through the manual option menu 80 is shown in Figures 3A and 3B respectively. Once the page has been designed, the printer driver, at step 54A, receives the data file of the page and then determines, through object identification, the elements making up the page and tags these accordingly. In the example shown, the page includes four elements, a photograph, a pie chart a title in colour and text in black.

In the automatic mode shown in Figure 3A, at step 55A, the system assigns the correct halftoning and colour map to each colour object. These parameters will automatically adjust the printer so as to produce the optimum printed version of the generate page. The generated data page is then sent to the printer, at step 56A, for printing at step 57A. The result is a colour page equivalent to the view displayed on the monitor 45.

On the other hand, in the manual mode, the objects making up the page are tagged at step 54B in similar manner as in the automatic mode. Following this tagging, the user is given the option to customise the printer's halftoning, lightness and colour settings to change the appearance of the page. The adjusted data page is then transmitted to the printer at step 56B for printing at step 57B to produce a printed page equivalent to the adjusted page.

The above-described colour modes are preferably displayed in menu format. Referring to Figure 4, prior to the actual printing step 57A or 57B, the user is presented with a printing menu providing various printing options. Figure 4 shows two possible menu formats, the upper format 60 shown giving various printer set up options which are treated as default settings in a printer set up menu for the lower printing format 60'. The Print setup menu may be of the type provided in Windows 3.1 (TM) developed by Microsoft Corporation.

When the manual colour mode is selected, the system displays menus of the type shown in Figure 5.

The preferred embodiment makes use of and performs in the environment of well-known commercially available color-matching specifications and operating-system software whose use is very widespread. These are respectively Pantone^{R} Color and Microsoft's Windows^{R} 3.1; the following details accordingly, for definite-

ness, are couched in terms of these familiar modules. The role of Pantone in this environment is, in essence, as arbiter of what may be called "true" color; however, those skilled in the field will understand that even this represents simply an effort to provide a reliably expert evaluation of what is inherently subjective.

The preferred embodiment further has been embodied in color printing devices 56, 110 commercially available from the Hewlett Packard Company as its DeskJet® model 1200C and PaintJet® model XL300. in abbreviated form: DJ 1200C and PJ XL300 respectively.

Readers skilled in the art, however, will appreciate that the described embodiments are not limited to this environment and could be applied in any of a great variety of present and future color-matching/operating-system/ printer environments.

In Windows® 3.1, Microsoft developed the concept of a so-called "common print dialog" 70 (Fig. 4). This "dialog" screen is called from different points within the application or from Windows directly. When this dialog function 70 has been used, some features of the color-printing-driver 32 "Setup Dialog" screen 60 have been addressed already: these features are "Orientation" 71, "Media Size" (e. g., paper size) 73 and "Media Source" (e. g., paper source) 72.

These features therefore need not be presented to the user again in the print-driver 32 "Setup Dialog". With this in mind, the driver is best configured to display only a modified version 60' of the Setup Dialog 60 when the driver 32 is called from the common print dialog 70.

As shown in Fig. 5, the user options presented in the driver's "Manual Color Options" screen 80 are divided into two categories. The first category 81-93 contains the settings labeled "Printed Color Control" 81 and "Halfton-ing" 90. These options can be selected on an object-by-object 41-43 basis; the object types in this case are text 85, graphics 86 and photos -- or photo-like images -- 87.

Table 1: LIGHTNESS SLIDER settings and functions

Color Control	γ value for indicated slider setting				
	lightest	lighter	normal	darker	darkest
Accurate Match	0.5	0.7	1.0	1.2	1.4
Clear and Vibrant	0.5	0.7	1.0	1.2	1.4
No Adjustment	0.3	0.4	0.6	0.8	1.0

In other words, the Printed Color Control 81 can be set for text 85 to a mode that is different from the mode or modes selected for graphics 86 and for photographic images or the like 87. The Halftoning method 90 too can be different for the three different types of objects 85-87.

The second category 96, 97 contains the "Lightness" slider 96 and the "Lookup-Table Colors" (e. g.,"Pantone Colors") mode control 97. In the preferred embodiment these options can be set only on a job-by-job basis. This means that the Lightness 96 and Lookup-Table mode 97 act upon the entire job regardless of what types of objects are in each job (or on each page of the job).

The driver adjusts the incoming red, green and blue (RGB) data by applying a "gamma" (contrast function) correction to produce adjusted RGB data as indicated in Table 1.

In configuring the preferred embodiment, the color transfer functions of both the DJ 1200C and the PJ XL300 were characterized to create a lookup (e. g., Pantone® Color) table to be incorporated into the driver. When this mode is selected, the driver checks all incoming RGB values against the key values provided by the lookup table. If there is an exact match, then the driver maps (i. e., translates) the incoming RGB value into the correct (as discerned by Pantone) RGB value to send to the printer – to produce the closest approximation of the Pantone color selected.

Table 2: PRINTED COLOR CONTROL/HALFTONING selections for TEXT and GRAPHICS

Halftone setting	Color-Control setting			key
	Clear and Vivid	Accurate Match	No Adjustment	
Scatter	HMS color map (#1)	Accurate map (#8)	RGB pass-through	_color "map"
	HPL noise	HPL noise	HPL noise	_half-toning
Cluster	HMS color map (#2)	Accurate map (#9)	RGB pass-through	_color "map"
	Current Cluster dither	Current Cluster dither	Current Cluster dither	_half-toning
Pattern	HMS color map (#3)	Accurate map (#10)	RGB pass-through	_color "map"
	Current Bayer dither	Current Bayer dither	Current Bayer dither	_half-toning

Only so-called "Plain Paper" has been Pantone certified for the DJ 1200C; and "Special Paper" for the PJ XL300. In operating a system according to the preferred embodiment, if a user attempts to select the "Look-up-Table Colors" ("Pantone Colors") checkbox when the appropriate type 74/74' of medium is not selected, a warning message appears.

"Defaults" button 98 (Fig. 5) -- This control resets all the user options in this dialog to the factory-default values for the prevailing mode. These defaults 85'/86'/-87'/85"/86"/87" are shown in the "Manual Color Options Dialog" screen display 80 of Fig. 5.

"Calibrate Screen" button 99 -- This control brings up the so-called "Calibration" utility. An operator will use this when it is desired to recalibrate the monitor in order to assemble and store 14 new color maps (tables) for an "Accurate Screen Match" mode.

Table 3: PRINTED COLOR CONTROL/HALFTONING selections for PHOTOGRAPHIC images

Halftone setting	Color-Control setting			key
	Clear and Vivid	Accurate Match	No Adjustment	
Scatter	HMS color map (#4, 5)	Accurate map (#8, 11)	RGB pass-through	color "map"
	HPL noise with CV or CMYK Err. Diff.	HPL noise with CV or CMYK Err. Diff.	HPL noise with CV or CMYK Err. Diff.	half-toning
Cluster	HMS color map (#6)	Accurate map (#9)	RGB pass-through	color "map"
	Current Cluster dither	Current Cluster dither	Current Cluster dither	half-toning
Pattern	HMS color map (#7)	Accurate map (#10)	RGB pass-through	color "map"
	Current Bayer dither	Current Bayer dither	Current Bayer dither	half-toning

Tables 2 and 3 show the types of color matching (or "mapping" 82-84) and halftoning 21-27, 91, 92 (Figs. 6 through 9) that are implemented in the driver 32 for the various user-selectable options or settings in this user-interface dialog 80. Following are definitions of the table entries.

"HMS type color map" 82 (Fig. 9) -- This is a color-correction relationship used to boost the vibrancy of the hue associated with an input or given RGB value, as indicated by the designation "Vivid Color" in Figs. 6 through 9.

"Accurate color map" 83 -- This is an alternative relationship created when a user calibrates the monitor with screen calibration 99 (that is, using the "Calibration" utility 14 mentioned above) in order to get printed output 57 that matches what is on the user's screen 45. This map 83 is then called up if the user actuates 81 (Fig. 6) the "Match Screen" selection 83 of Fig. 5.

"No Adjustment" 84 -- With this setting the driver 32 does not do any processing of incoming RGB data. This is the mode an operator may use to control exactly the RGB values that are sent to the printer 56.

"HPL Noise with CV" 21 (Figs. 6, 7 and 9) -- This "Halftoning" 90 option utilizes a 128x128-byte so-called "Noise dither" matrix 27, along with conversion 25 of RGB data into "Color Vector" ("CV") data. This option provides quality closer to that of "Error Diffusion" (see below), with about the speed of normal dithering 91, 92.

This option is invoked in the "Fast" 68 or "Normal" 67 printing mode when "Scatter" halftoning is selected. "HPL Noise" halftoning 93 is disclosed in the above-mentioned copending applications Serial 57,244 and 60,285; and "HPL Noise with CV" 21 is disclosed in European patent applications No. (N2990) and (N2991), filed concurrently with this document.

"CMYK Err Diff" 22 -- This "Halftoning" option utilizes a CMYK (cyan-magenta-yellow-black) "Error Diffusion" algorithm. This provides the highest-quality output (for photograph-like images only), but is the slowest halfton-ing method.

It is used when the system is set to its "High Quality" printing mode 6o and "Scatter" halftoning 93 is selected. CMYK Error Diffusion 22 is disclosed in European patent application no. (N2989), filed concurrently herewith.

"Current Cluster dither" -- This is the same "Cluster dither" 91 that is in earlier DJ 1200C and PJ XL300

printers- This method is faster than Error Diffusion 22 and provides good edge definition for text and graphics.

"Current Bayer dither" - This is the same so-called "Pattern dither" 92 that is in earlier DJ 1200C and PJ XL300 printers - again, those uninfluenced by the described embodiments. This method has the same speed as Cluster dither 91 and has been preferred by some users.

The total number of maps needed is shown also in the matrices above. There will be 11 maps needed for all the combinations of color matching modes and half tone methods.

This is a significant increase in the number of maps shipped and will definitely put the space required for installation above the amount that can fit onto one disk. Therefore, the decision has been made to ship the driver on 2 disks to accomodate this.

The processing flow shown in Figure 6 for the three possible print options of automatic or manual colour or monochrome will be apparent to the skilled person without specific description of the various steps shown.

Figure 7 shows a processing flow chart for pages containing various types of object. The first step in the process is to determine the element or object type. In dependence upon the object type, processing continues along specific paths to set the halftone, noise dither, cluster dither and pattern dither appropriate for the identified object. In the case of photographs, the routine allows for the selection of three different print modes: fast, normal and high quality. The various steps in the flow chart will be apparent to the skilled person without further explanation herein.

Figure 8 shows an embodiment of flow chart for adjusting the colour settings manually, in which case each adjustment is made in dependence upon the determined object type. The flow chart will be self-explanatory to the skilled person.

There are two possible implementations of "Scatter for Photos" 93, both already introduced above. One is the "HPL Noise with CV" dither 21 -- sometimes called simply "CV Noise" or "Special Dither". In the preferred embodiment this is the default, since it is fast and gives better output quality (when compared to cluster or pattern) for raster images. The other implementation is "CMYK Error Diffusion" 22, which as previously noted provides even better quality but with a significant degradation in speed.

The selection between the two is based on the user-interface Print Quality 65 mode setting. The High Quality 66 setting automatically selects CMYK Error Diffusion 22, whereas each of the Fast 68 and Normal 68 settings selects CV Noise 21.

The total number of color-correction lookup tables or "maps" needed is also represented in Tables 2 and 3. Eleven maps are needed for all the combinations of color-matching modes and halftoning methods. This is a significant increase in the number of maps provided as part of a color-printer driver, relative to the prior art.

As Fig. 9 shows, the input to the entire system is twenty-four-bit RGB, and the output is three-bit RGB sent to the printer. The steps involved are: choosing one of the color maps (HMS/Vivid, Accurate, or none) and mapping the color to another twenty-four-bit RGB value -- and then going on to halftoning methods.

In the case of Noise Dither 21, preambles to halfton-ing are conversion 25 of the second twenty-four-bit RGB values to CV space, and some color processing 26in CV space; then the halftoning 27 is done in CV space. For Cluster 91, Pattern 92 and Error Diffusion 22, the preferred embodiment performs the halftoning in RGB space.

Table 4: Assignment of rendition functions for object types

<table>
<tr><th colspan="3">Type</th><th colspan="2">Rendering location</th></tr>
<tr><td colspan="3">All Text</td><td colspan="2" rowspan="3">Printer</td></tr>
<tr><td colspan="3">All Graphics Objects</td></tr>
<tr><td rowspan="3">1-, 4-, and 8-bit photo-like images</td><td colspan="2">Cluster or Pattern Halftoning</td></tr>
<tr><td rowspan="2">Scatter Half-Toning</td><td>Noise</td><td rowspan="3">Windows Driver</td><td>Normal/Fast</td></tr>
<tr><td>Err. Diff.</td><td rowspan="2">High Quality</td></tr>
<tr><td colspan="3">All 24-bit photo-like images</td></tr>
</table>

The color-matching portion of the color path is always done in the driver 32. The CV processing and halftoning 21-27, 91-93 are done either in the driver 32 or in the printer 56, depending on the type 41-43 of object being rendered.

Table 4 shows where objects of different types are rendered. All objects that are not already rendered in the application 31 (which is to say, most objects) are either rendered in the Windows driver or in the printer 56 firmware.

For objects that are to be rendered in the printer 56, color processing is first done in the driver 32 – this encompasses the Color Matching 81, Lightness slider 96, and Lookup-Table (Pantone) Colors 97 settings. Then the object is sent from the Windows driver to the printer with associated twenty-four-bit final RGB values.

Based on the user's halftoning selections 90 in the user interface 80 -- or on the automatic halftoning invocations 93 etc. based on the user's mode selections 65-68 -- a command is also sent to the printer 56 to set the appropriate rendering mode 21/22/91/92 in the printer. The printer firmware 56 is then responsible for rendering all the objects and, in some cases, for scaling raster images.

As Table 4 indicates, the only objects that are rendered in the Windows driver are photograph-like images that use the Scatter halftoning 93, and all 24-bit photo-like images. The reason the Scatter halftoning 93 is rendered in the driver is that not all printers support the Scatter mode 93; and the only way to support both Error Diffusion 22 and Noise dither 21 on all printers is to provide them in the driver.

The twenty-four-bit images are rendered in the driver regardless of the halftoning mode in order to minimize the amount of data sent over the printer interface. Each twenty-four-bit RGB pixel is ordinarily halftoned down to three bits per pixel, which inherently provides an eight-to-one compression -- in addition to the printer-command-line compression on those three-bit pixels.

It will thus be appreciated from the foregoing description that many improvements can be provided.

In the past users have only had limited control in the selection of rendering options and color-correction options. That is, they have been limited to choosing one particular rendering option and/or one particular color-correction ootion for an entire document.

With the preferred embodiments, on one hand it is possible for a sophisticated user to select an independent rendering option and independent color-correction option for each type of object (e. g., text, business graphics. and photographic images). For example, in the printer-driver dialog screens shown in the drawings, a user can select a Scatter 93 halftone for photographic images, a Pattern 92 halftone for business graphics, and a Cluster 91 halftone for text.

In addition, color-correction options can be chosen for each object type independently of the halftoning method. This independent control of halftoning and color correction for each object gives the sophisticated user a multitude of options and thus very fine control of the quality and appearance of the printed output.

On the other hand, for hurried or unsophisticated users – or those preparinq material in which color quality is not crucial – there is the ability to render and color-correct objects based on their respective types, with defaults and a minimum of decision-making (e. q., selection of "Fast" 68 and "Automatic Color" 62). Hence it is possible to preselect halftoning and color-correction options that are normally the best for each object type 41-43.

Thus there can be provided an automatic default that produces the best quality output for most users of a particular printer -- but also optional manual settings that can be changed by the more-demanding user.

Furthermore, as set forth earlier another printout quality feature is preferably automatically implemented as a default in the printer system. For example, in conceiving the preferred embodiment it was determined that users prefer a particular error-diffusion halftoning 22 over other kinds of dither halftoning.

This selection has been incorporated into (or, as phrased just above, automatically implemented as a default in) the print-quality print-mode options of the sort used by many manufacturers. Such print-mode options allow users to choose settings such as to optimize the printer technology itself for either faster output or higher-quality output.

It was discovered that this optior. could also be used to control an analogous kind of tradeoff within the printer driver itself, and in particular solved the problem of selecting – with a minimum of human-user decisions and entry operations -- a halftoning method to use for certain complex objects such as photographic images. Thus, if the user chooses a print quality setting of "high quality" 66, the driver will perform CMYK error diffusion 22 to render all raster images (e. g., photosraph-like images), while settings of "Normal" 67 or "Fast" 63 for the print mode will cause the driver 32 to perform noise dithering 21 on all raster images.

The disclosures in United States patent application no. 08/189,006, from which this application claims priority, and in the abstract accompanying this application are incorporated herein by reference.

Claims

1. A method of printing a composite document including at least one object of one of a plurality of object types (41-43), including the steps of identifying the type of the or each object of the document; and using a predetermined first rendering option to print the or each object of a first identified object type (41).

2. A method according to claim 1, comprising the step of employing a predetermined second rendering option to print objects of one or more object types (41,43) different from said first object type (41).

3. A method according to claim 1 or 2, comprising the step of employing a specific print rendering option for each identified object type.

4. A method according to claim 1, 2 or 3, wherein a half-tone colour rendering option is used for objects identified as being of a photographic type.

5. A method according to claim 1, 2 or 3, wherein a colour matching colour rendering option is used for objects identified as being of a photographic type.

6. A method according to any preceding claim, wherein all raster data commands are identified as being of a photographic type, all text objects are identified as being of a text type and/or all objects which are not text commands are identified as being of a graphics type.

7. A printing system for printing colour documents in a raster printer comprising a print (56) for applying printing material to media; a document source (60-99) for providing specifications of a composite colour document including non-text colour objects (41,42) and colour management means (44,45) for providing print rendering options which can be selectively enabled for said non-text colour objects.

8. A printing system according to claim 7, wherein said colour management means (44,45) is operative automatically to provide default settings for at least one of said print rendering options.

9. A printing system according to claim 7 or 8, wherein said colour management means (44,45) is operative to provide half-tone print rendering options which can be enabled for said non-text colour objects.

10. A printing system according to claim 7, 8 or 9, wherein said colour management means (44,45) is operative to provide half-tone print rendering options and/or colour matching print rendering options which can be separately enabled for two different types of non-text colour objects.

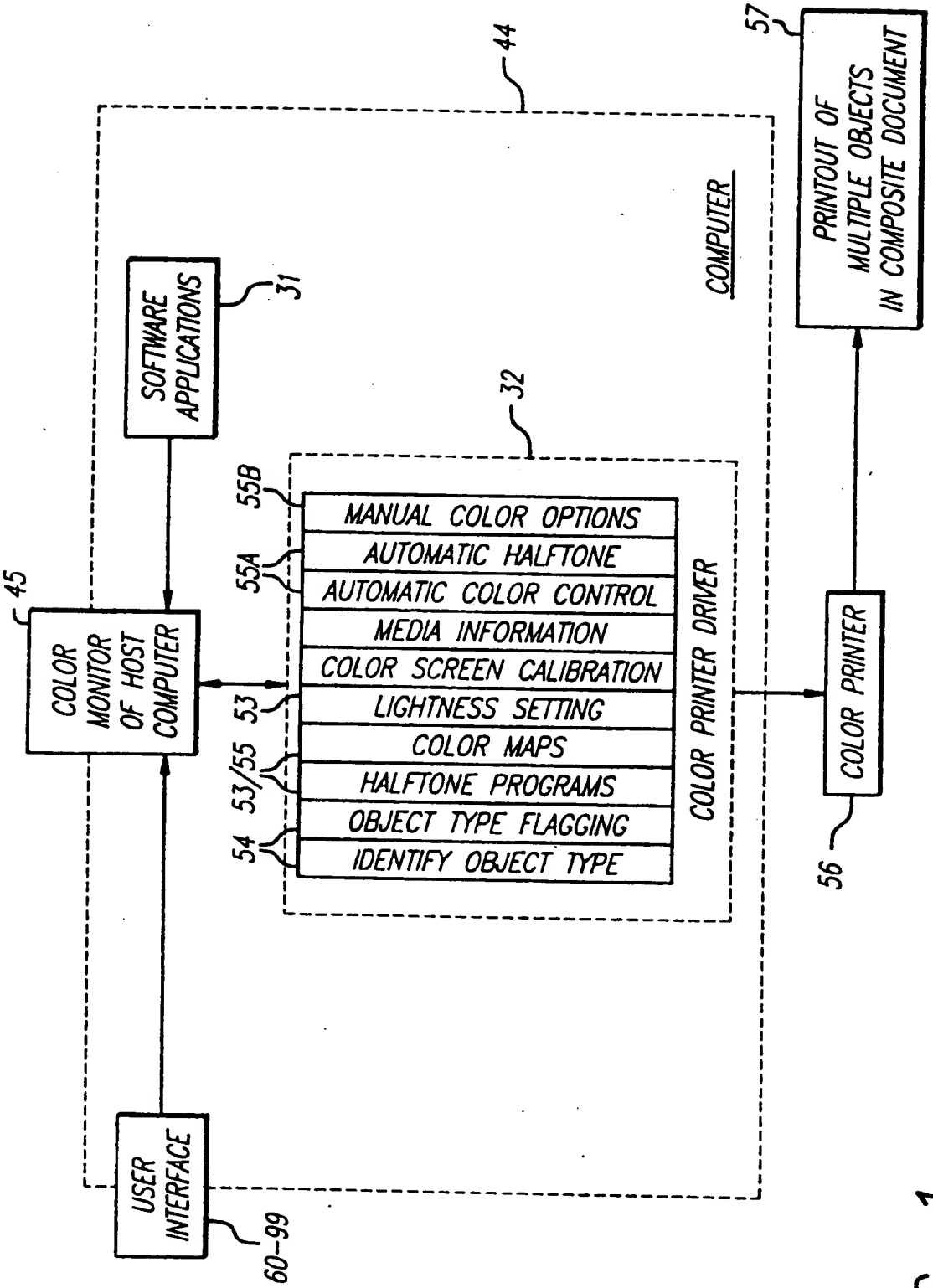

44
57
PRINTOUT OF MULTIPLE OBJECTS IN COMPOSITE DOCUMENT
COMPUTER
SOFTWARE APPLICATIONS
31
32
55B
MANUAL COLOR OPTIONS
55A
AUTOMATIC HALFTONE
AUTOMATIC COLOR CONTROL
MEDIA INFORMATION
COLOR SCREEN CALIBRATION
53
LIGHTNESS SETTING
COLOR MAPS
53/55
HALFTONE PROGRAMS
OBJECT TYPE FLAGGING
54
IDENTIFY OBJECT TYPE
COLOR PRINTER DRIVER
45
COLOR MONITOR OF HOST COMPUTER
COLOR PRINTER
56
USER INTERFACE
60-99

FIG. 1

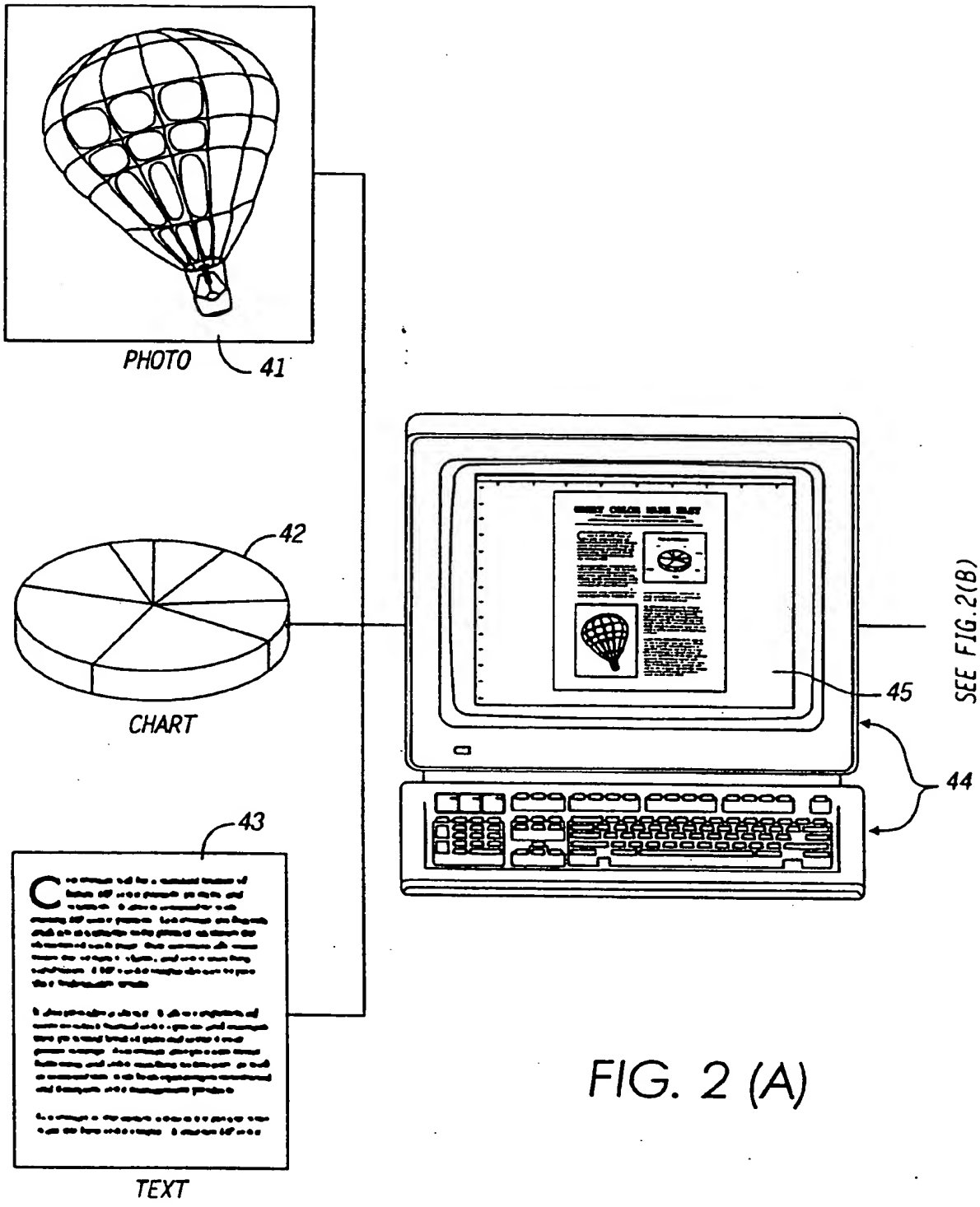


FIG. 2 (A)

FIG. 2 (B)

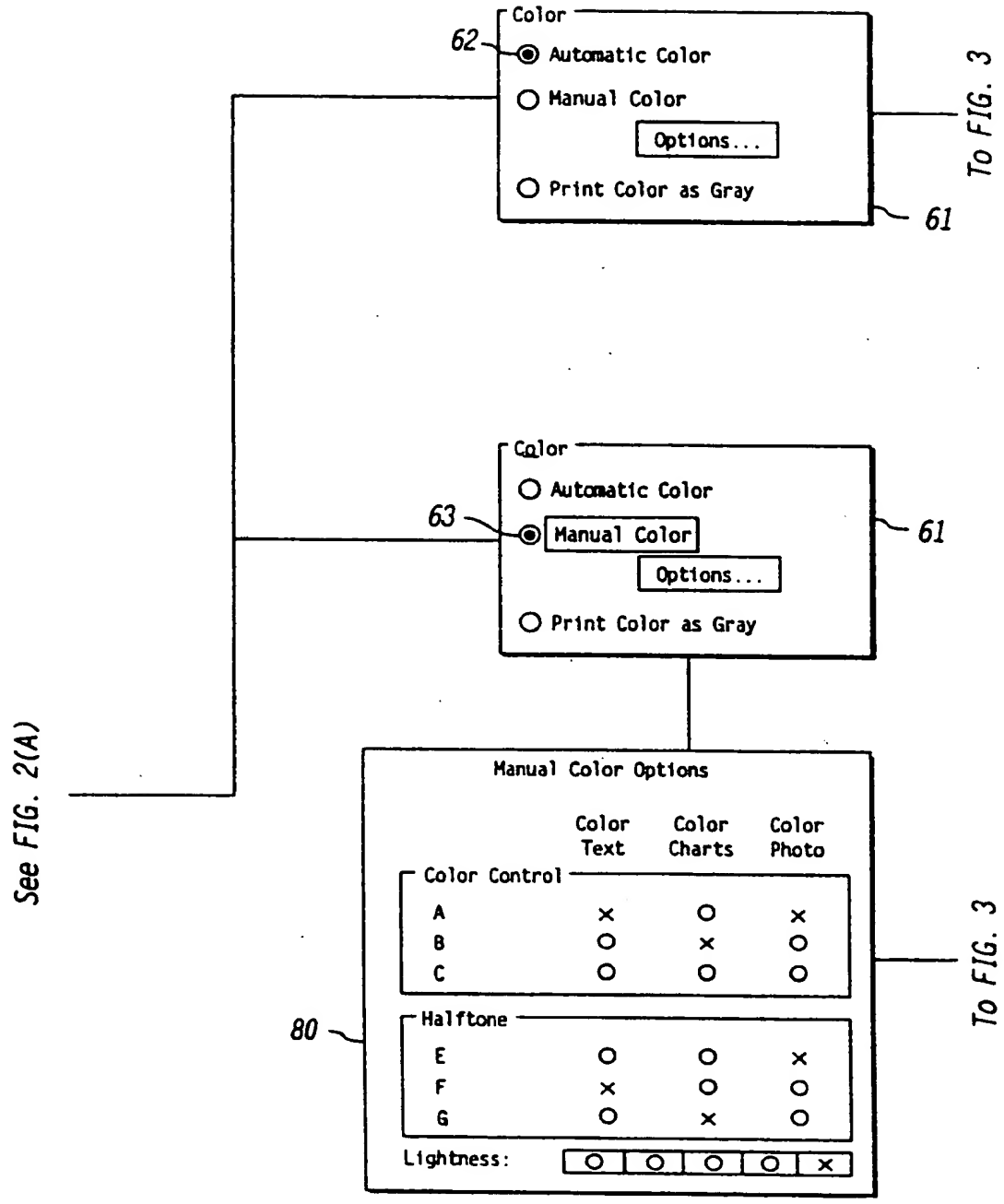

Color
62
Automatic Color
Manual Color
Options...
Print Color as Gray
61
To FIG. 3
Color
Automatic Color
63
Manual Color
Options...
Print Color as Gray
61
See FIG. 2(A)
Manual Color Options
Color Text
Color Charts
Color Photo
Color Control
A
B
C
80
Halftone
E
F
G
Lightness:
To FIG. 3

FIG. 3(A)

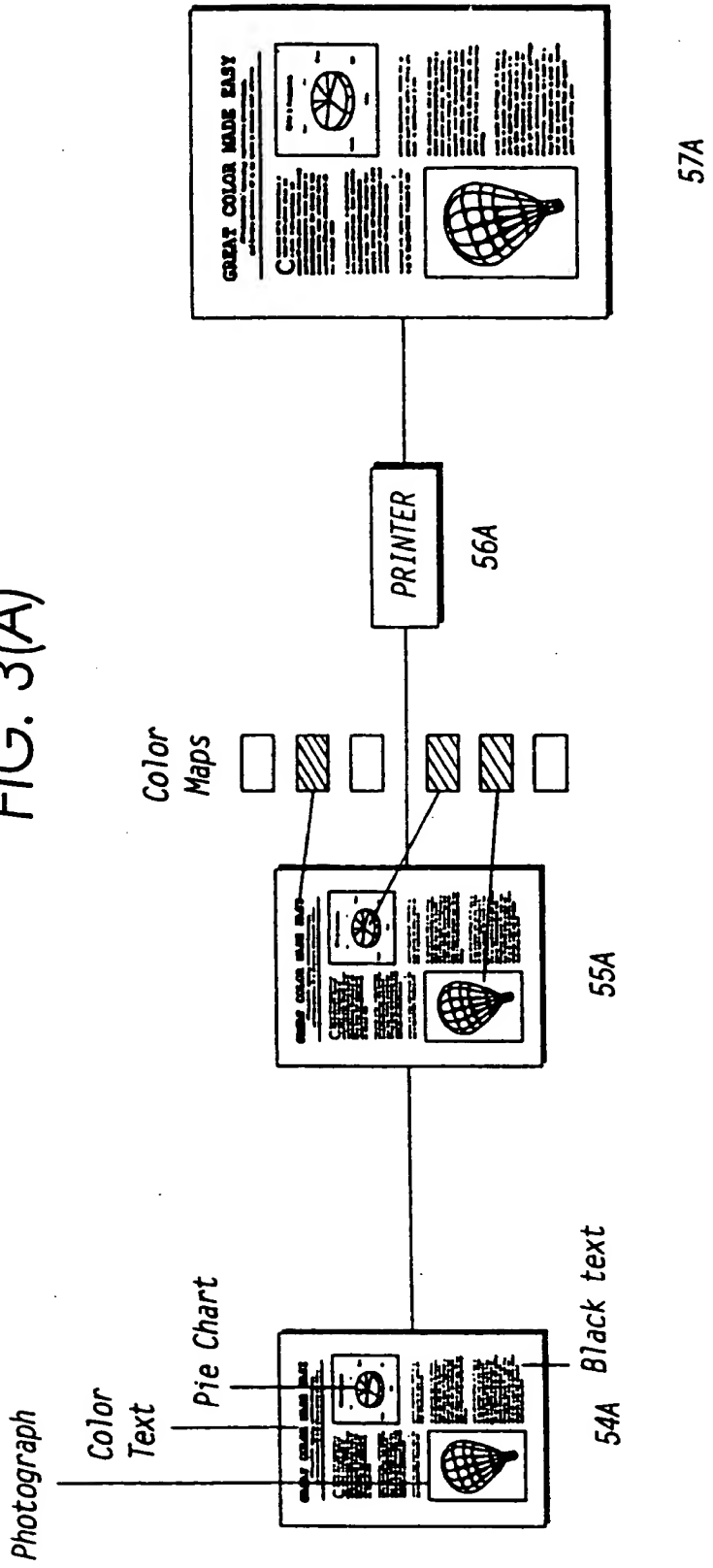
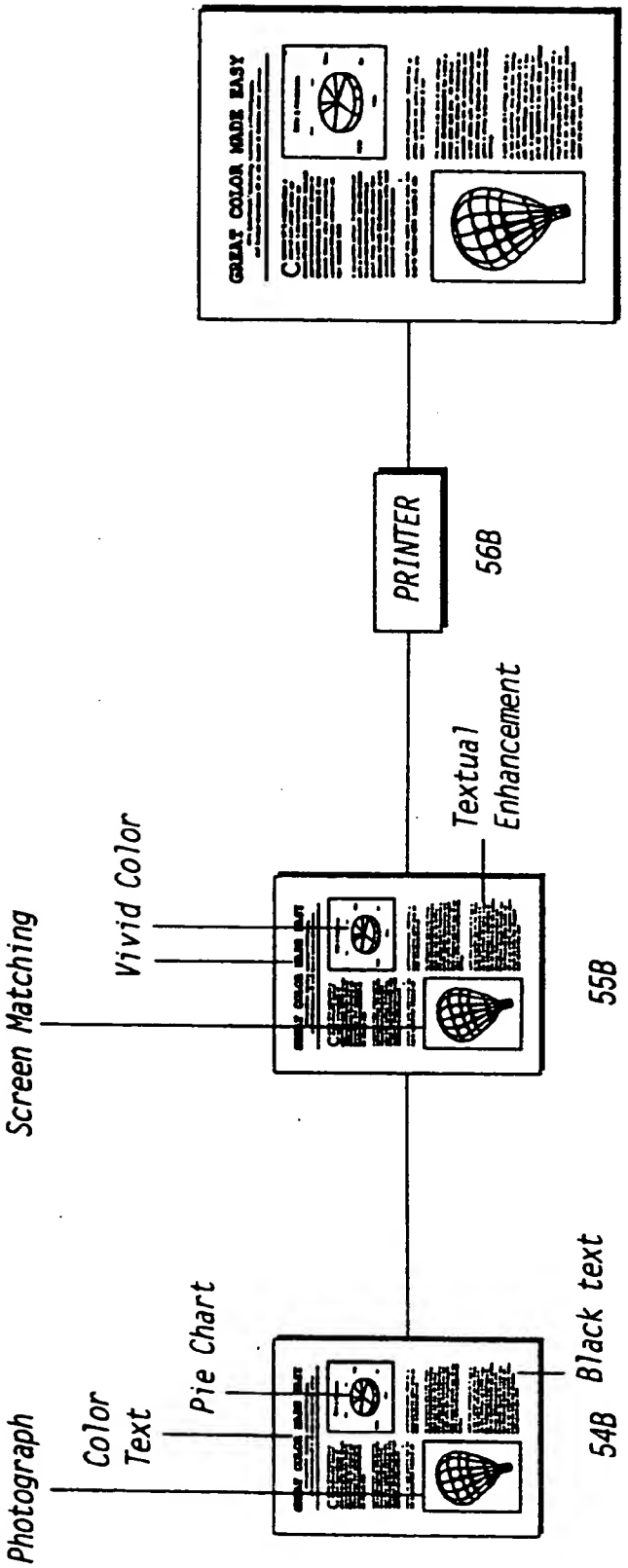

Photograph
Color Text
Pie Chart
Black text
54A
55A
Color Maps
PRINTER
56A
57A

FIG. 3(B)


GREAT COLOR MADE EASY
57B
PRINTER
56B
Textual Enhancement
Vivid Color
Screen Matching
55B
Black text
Pie Chart
Color Text
Photograph
54B

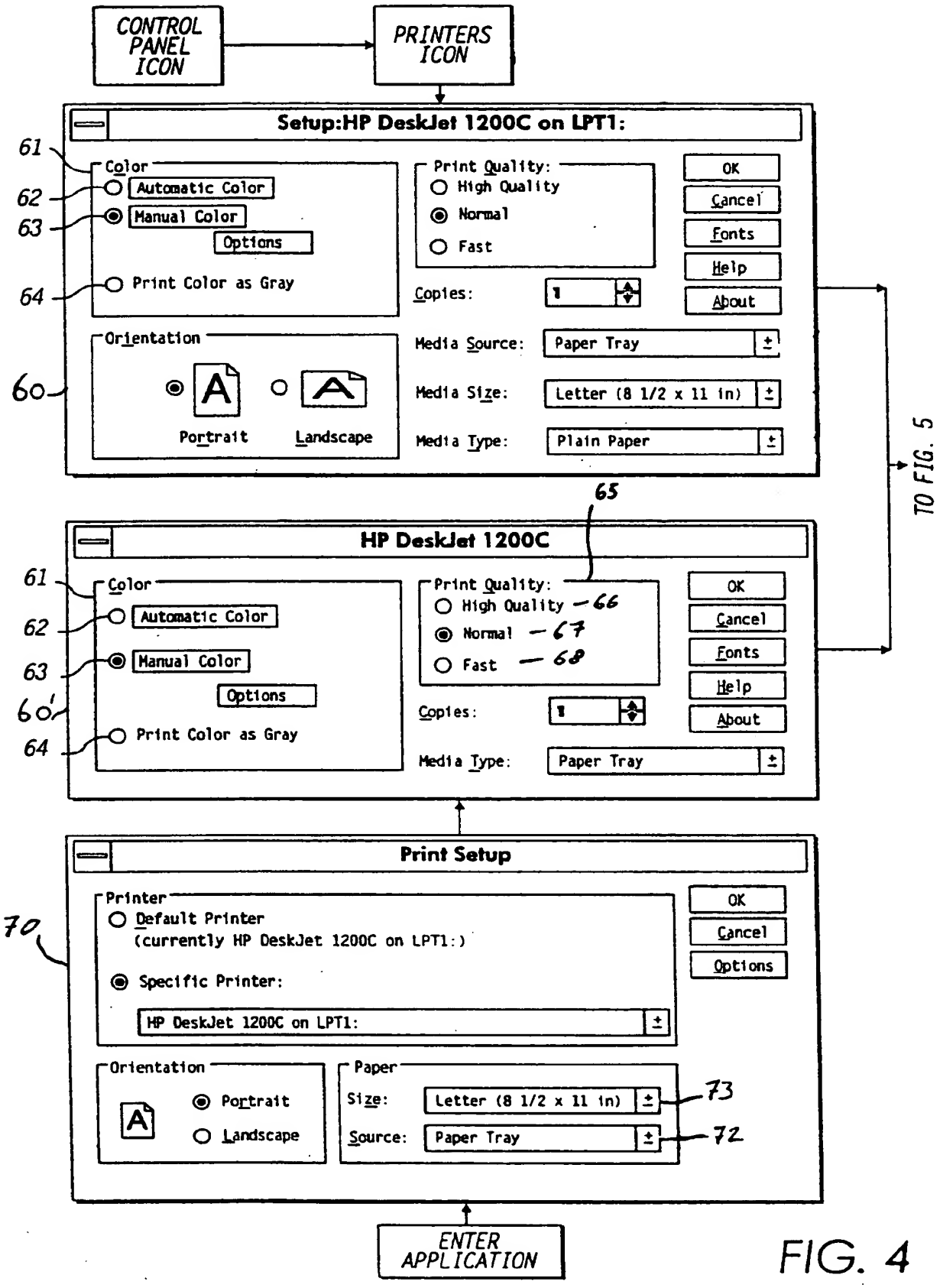
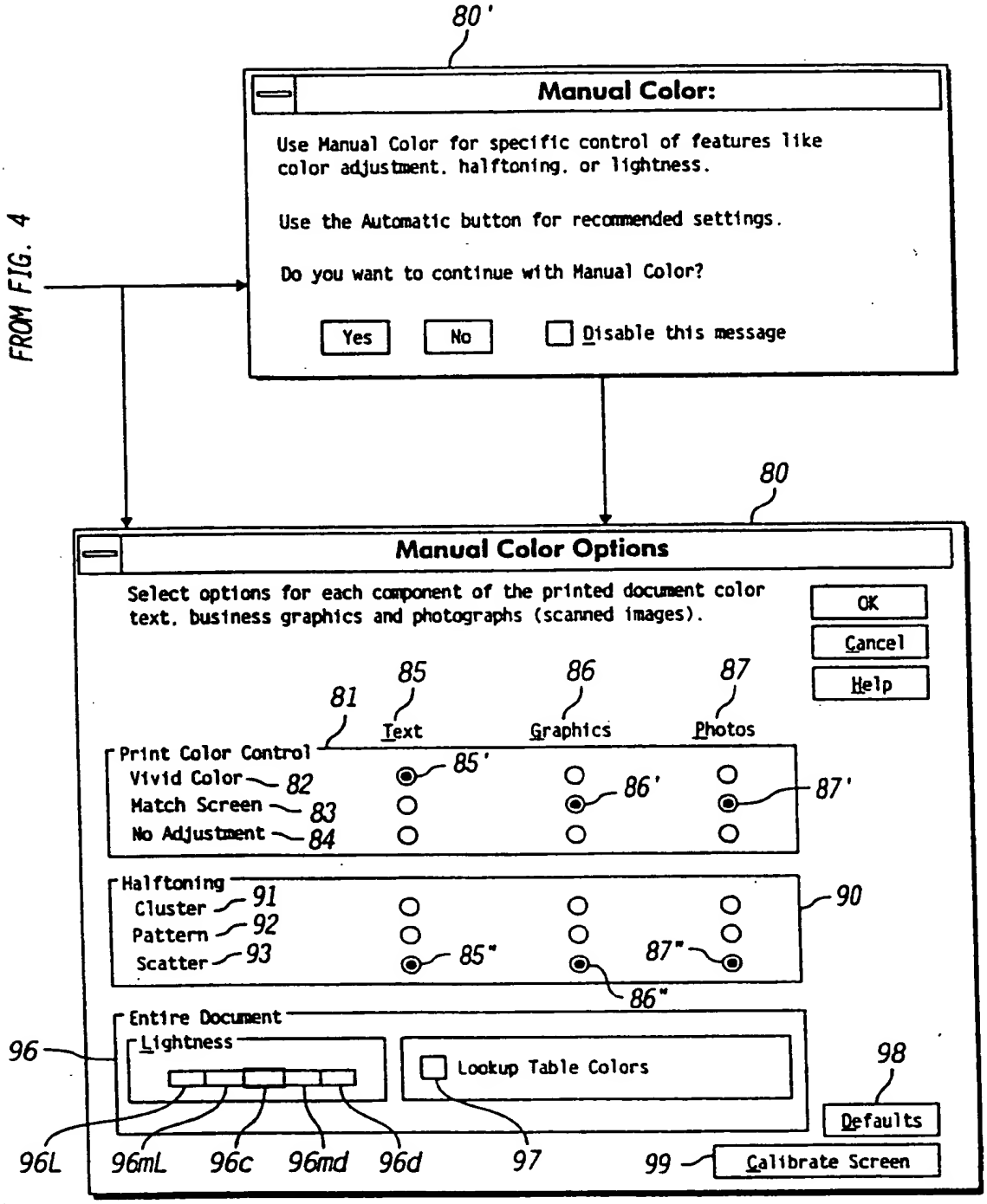

CONTROL PANEL ICON
PRINTERS ICON
Setup:HP DeskJet 1200C on LPT1:
61
Color
62
Automatic Color
63
Manual Color
Options
64
Print Color as Gray
Print Quality:
High Quality
Normal
Fast
OK
Cancel
Fonts
Help
About
Copies:
1
Orientation
60
Portrait
Landscape
Media Source:
Paper Tray
Media Size:
Letter (8 1/2 x 11 in)
Media Type:
Plain Paper
TO FIG. 5
65
HP DeskJet 1200C
61
Color
62
Automatic Color
63
Manual Color
Options
60'
64
Print Quality:
High Quality — 66
Normal — 67
Fast — 68
OK
Cancel
Fonts
Help
About
Copies:
1
Media Type:
Paper Tray
Print Setup
70
Printer
Default Printer
(currently HP DeskJet 1200C on LPT1:)
Specific Printer:
HP DeskJet 1200C on LPT1:
OK
Cancel
Options
Orientation
Portrait
Landscape
Paper
Size:
Letter (8 1/2 x 11 in)
73
Source:
Paper Tray
72
ENTER APPLICATION

FIG. 4

FIG. 5


FROM FIG. 4
80'
Manual Color:
Use Manual Color for specific control of features like color adjustment, halftoning, or lightness.
Use the Automatic button for recommended settings.
Do you want to continue with Manual Color?
Yes
No
Disable this message
80
Manual Color Options
Select options for each component of the printed document color text, business graphics and photographs (scanned images).
OK
Cancel
Help
81
85
Text
86
Graphics
87
Photos
Print Color Control
Vivid Color 82
Match Screen 83
No Adjustment 84
85'
86'
87'
Halftoning
Cluster 91
Pattern 92
Scatter 93
90
85"
86"
87"
Entire Document
Lightness
96
Lookup Table Colors
98
Defaults
96L
96mL
96c
96md
96d
97
99
Calibrate Screen

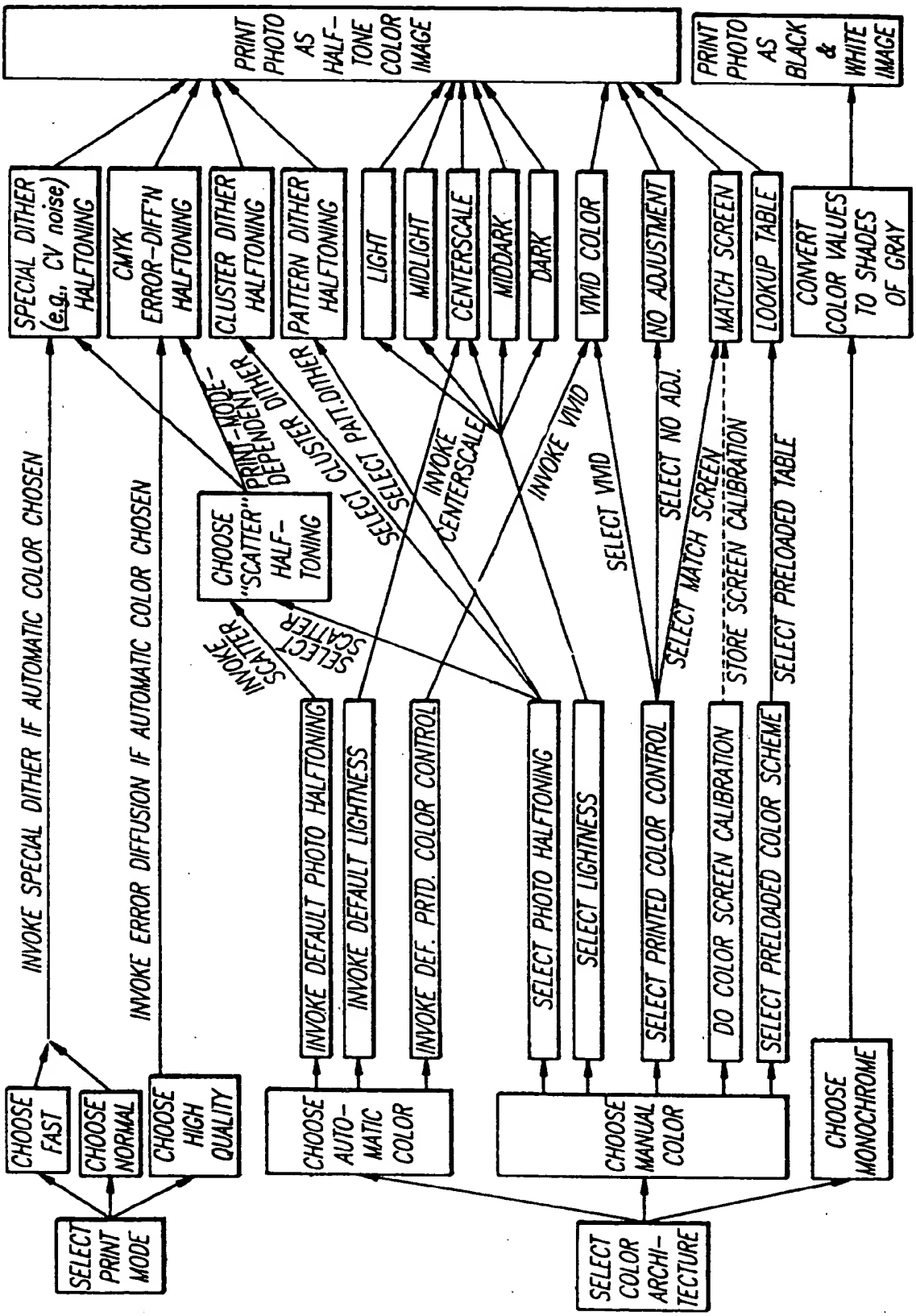
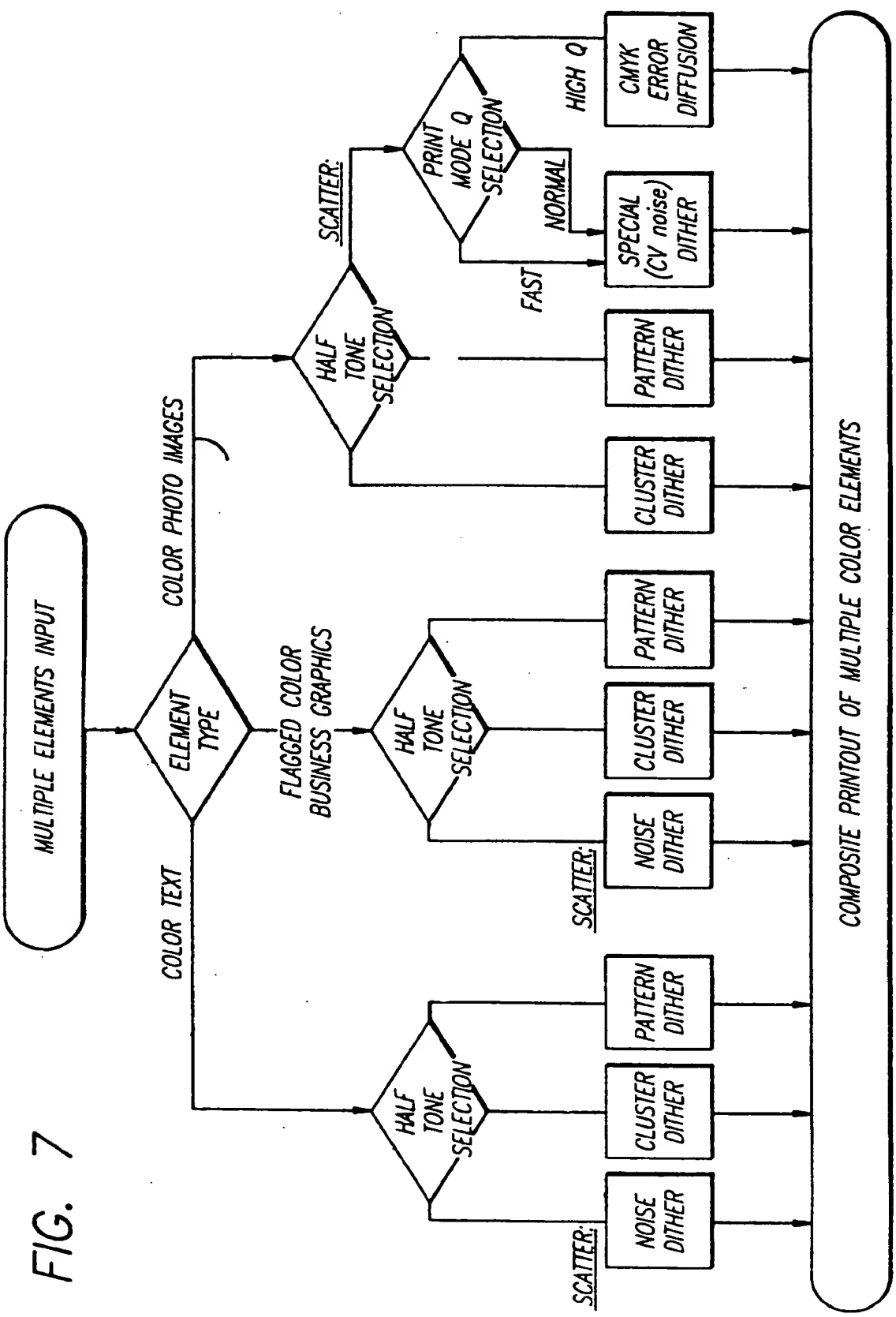

PRINT PHOTO AS HALF-TONE COLOR IMAGE
PRINT PHOTO AS BLACK & WHITE IMAGE
SPECIAL DITHER (e.g., CV noise) HALFTONING
CMYK ERROR-DIFF'N HALFTONING
CLUSTER DITHER HALFTONING
PATTERN DITHER HALFTONING
LIGHT
MIDLIGHT
CENTERSCALE
MIDDARK
DARK
VIVID COLOR
NO ADJUSTMENT
MATCH SCREEN
LOOKUP TABLE
CONVERT COLOR VALUES TO SHADES OF GRAY
INVOKE SPECIAL DITHER IF AUTOMATIC COLOR CHOSEN
INVOKE ERROR DIFFUSION IF AUTOMATIC COLOR CHOSEN
CHOOSE "SCATTER" HALF-TONING
PRINT-MODE-DEPENDENT DITHER
SELECT CLUSTER DITHER
SELECT PATT. DITHER
INVOKE CENTERSCALE
INVOKE VIVID
SELECT VIVID
SELECT NO ADJ.
SELECT MATCH SCREEN
STORE SCREEN CALIBRATION
SELECT PRELOADED TABLE
INVOKE SCATTER
SELECT SCATTER
INVOKE DEFAULT PHOTO HALFTONING
INVOKE DEFAULT LIGHTNESS
INVOKE DEF. PRTD. COLOR CONTROL
SELECT PHOTO HALFTONING
SELECT LIGHTNESS
SELECT PRINTED COLOR CONTROL
DO COLOR SCREEN CALIBRATION
SELECT PRELOADED COLOR SCHEME
CHOOSE FAST
CHOOSE NORMAL
CHOOSE HIGH QUALITY
CHOOSE AUTO-MATIC COLOR
CHOOSE MANUAL COLOR
CHOOSE MONOCHROME
SELECT PRINT MODE
SELECT COLOR ARCHI-TECTURE

FIG. 6

FIG. 7


MULTIPLE ELEMENTS INPUT
ELEMENT TYPE
COLOR TEXT
COLOR PHOTO IMAGES
FLAGGED COLOR BUSINESS GRAPHICS
HALF TONE SELECTION
SCATTER:
NOISE DITHER
CLUSTER DITHER
PATTERN DITHER
HALF TONE SELECTION
SCATTER:
NOISE DITHER
CLUSTER DITHER
PATTERN DITHER
HALF TONE SELECTION
SCATTER:
PRINT MODE Q SELECTION
FAST
NORMAL
HIGH Q
SPECIAL (CV noise) DITHER
CLUSTER DITHER
PATTERN DITHER
CMYK ERROR DIFFUSION
COMPOSITE PRINTOUT OF MULTIPLE COLOR ELEMENTS

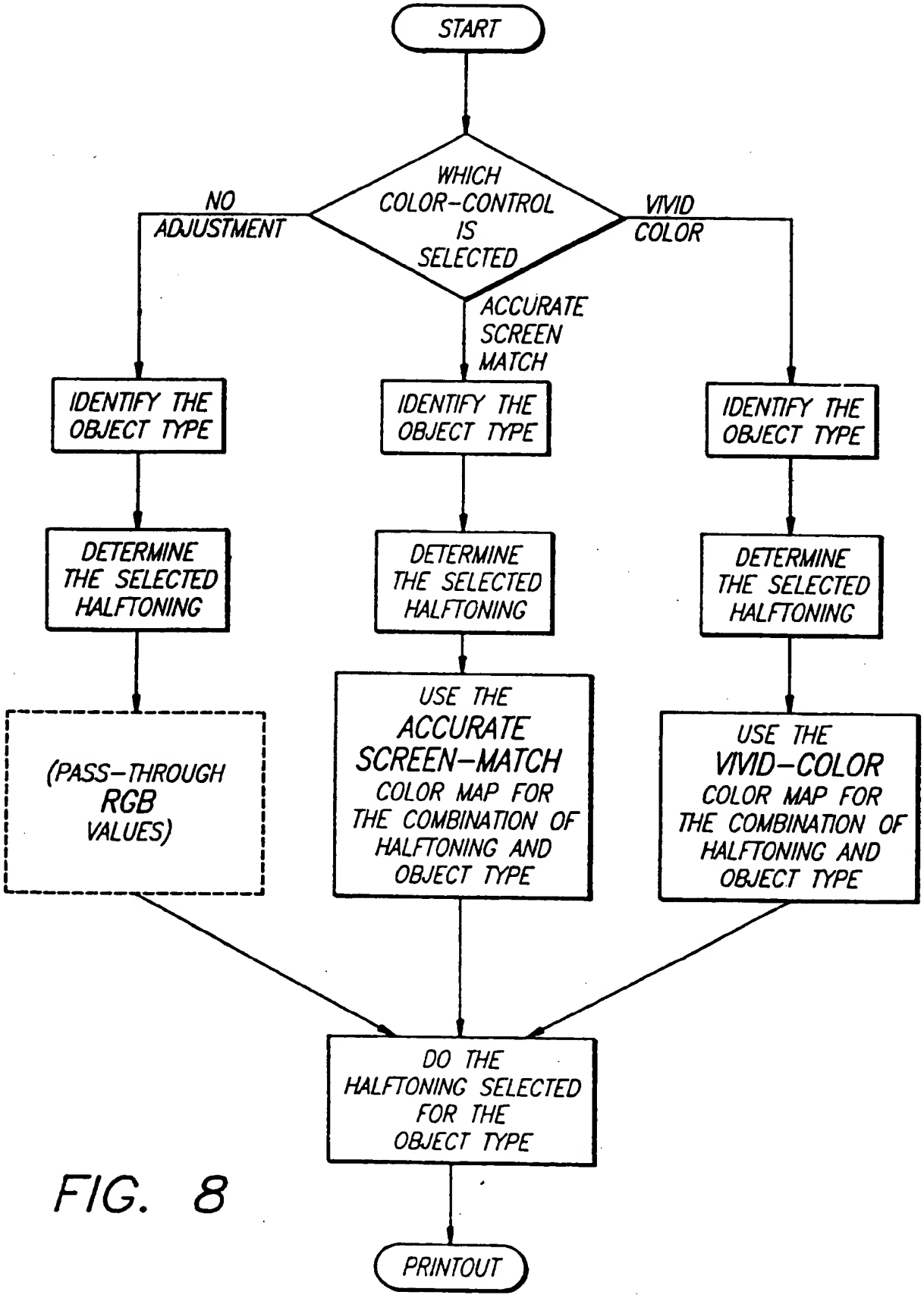

START
WHICH COLOR-CONTROL IS SELECTED
NO ADJUSTMENT
ACCURATE SCREEN MATCH
VIVID COLOR
IDENTIFY THE OBJECT TYPE
IDENTIFY THE OBJECT TYPE
IDENTIFY THE OBJECT TYPE
DETERMINE THE SELECTED HALFTONING
DETERMINE THE SELECTED HALFTONING
DETERMINE THE SELECTED HALFTONING
(PASS-THROUGH RGB VALUES)
USE THE ACCURATE SCREEN-MATCH COLOR MAP FOR THE COMBINATION OF HALFTONING AND OBJECT TYPE
USE THE VIVID-COLOR COLOR MAP FOR THE COMBINATION OF HALFTONING AND OBJECT TYPE
DO THE HALFTONING SELECTED FOR THE OBJECT TYPE
PRINTOUT

FIG. 8

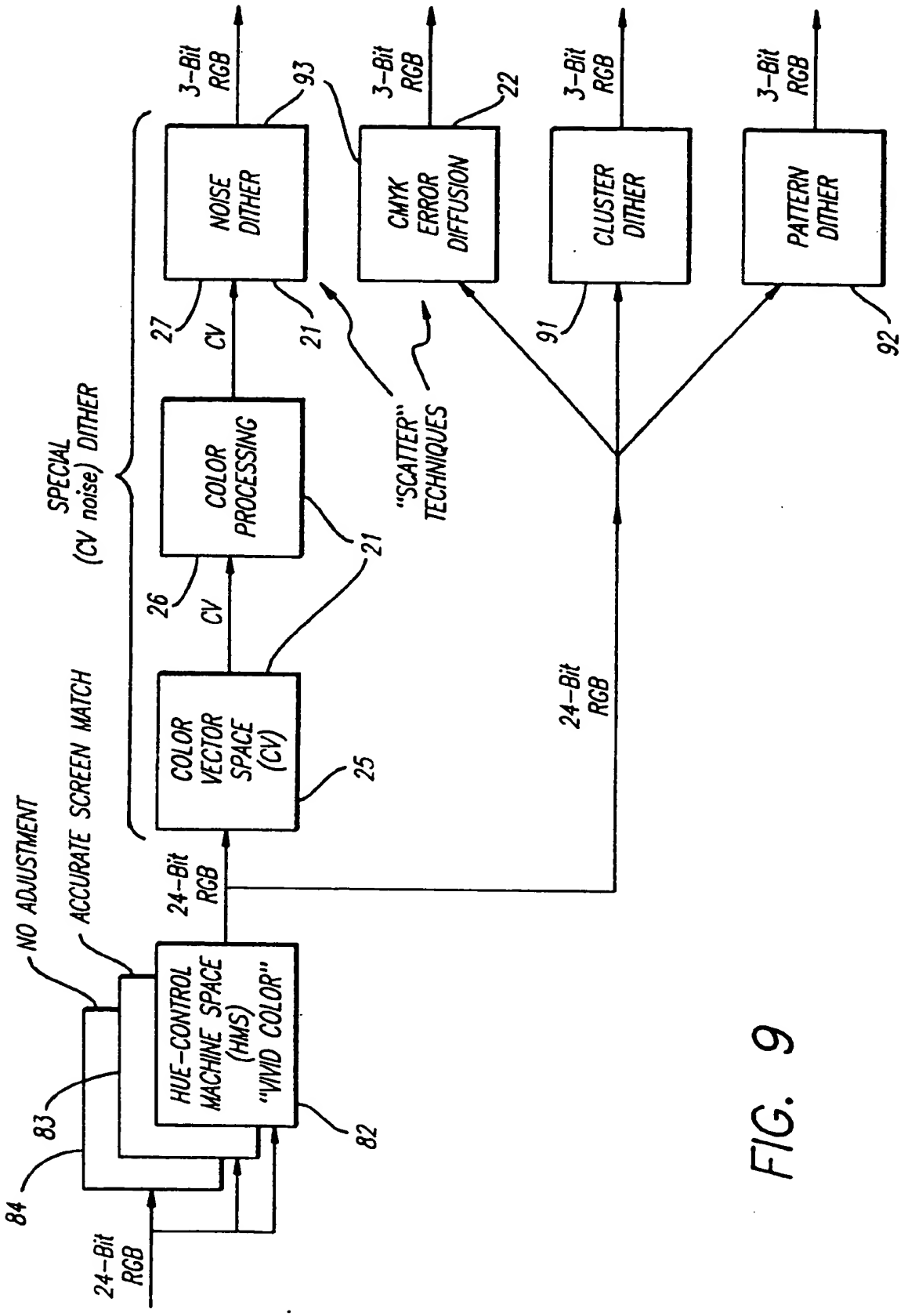

24-Bit RGB
84
83
HUE-CONTROL MACHINE SPACE (HMS) "VIVID COLOR"
82
NO ADJUSTMENT
ACCURATE SCREEN MATCH
24-Bit RGB
COLOR VECTOR SPACE (CV)
25
CV
26
COLOR PROCESSING
21
CV
27
SPECIAL (CV noise) DITHER
NOISE DITHER
3-Bit RGB
93
21
"SCATTER" TECHNIQUES
CMYK ERROR DIFFUSION
3-Bit RGB
22
24-Bit RGB
91
CLUSTER DITHER
3-Bit RGB
92
PATTERN DITHER
3-Bit RGB

FIG. 9

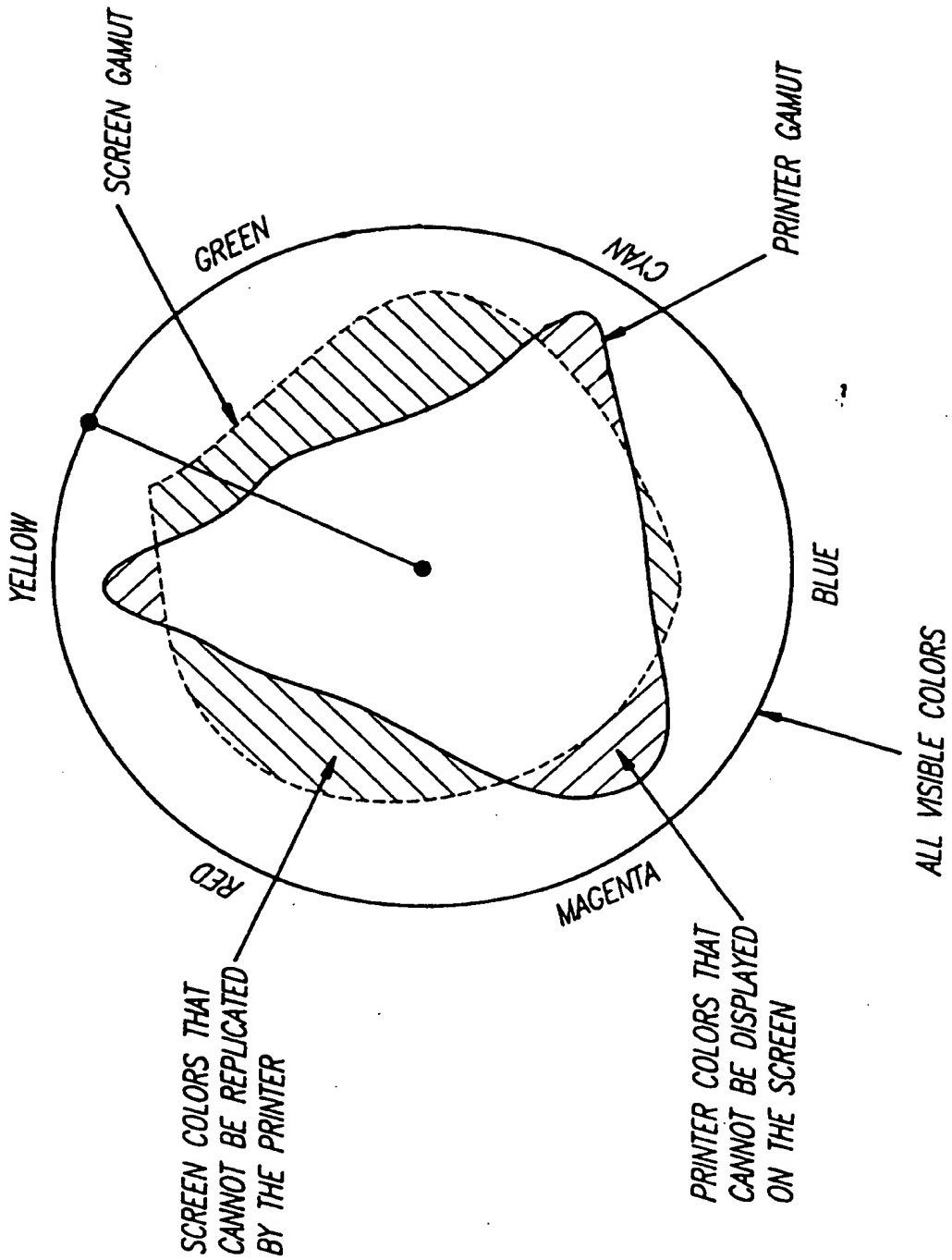

SCREEN GAMUT
PRINTER GAMUT
GREEN
CYAN
YELLOW
BLUE
RED
MAGENTA
ALL VISIBLE COLORS
SCREEN COLORS THAT CANNOT BE REPLICATED BY THE PRINTER
PRINTER COLORS THAT CANNOT BE DISPLAYED ON THE SCREEN

FIG. 10

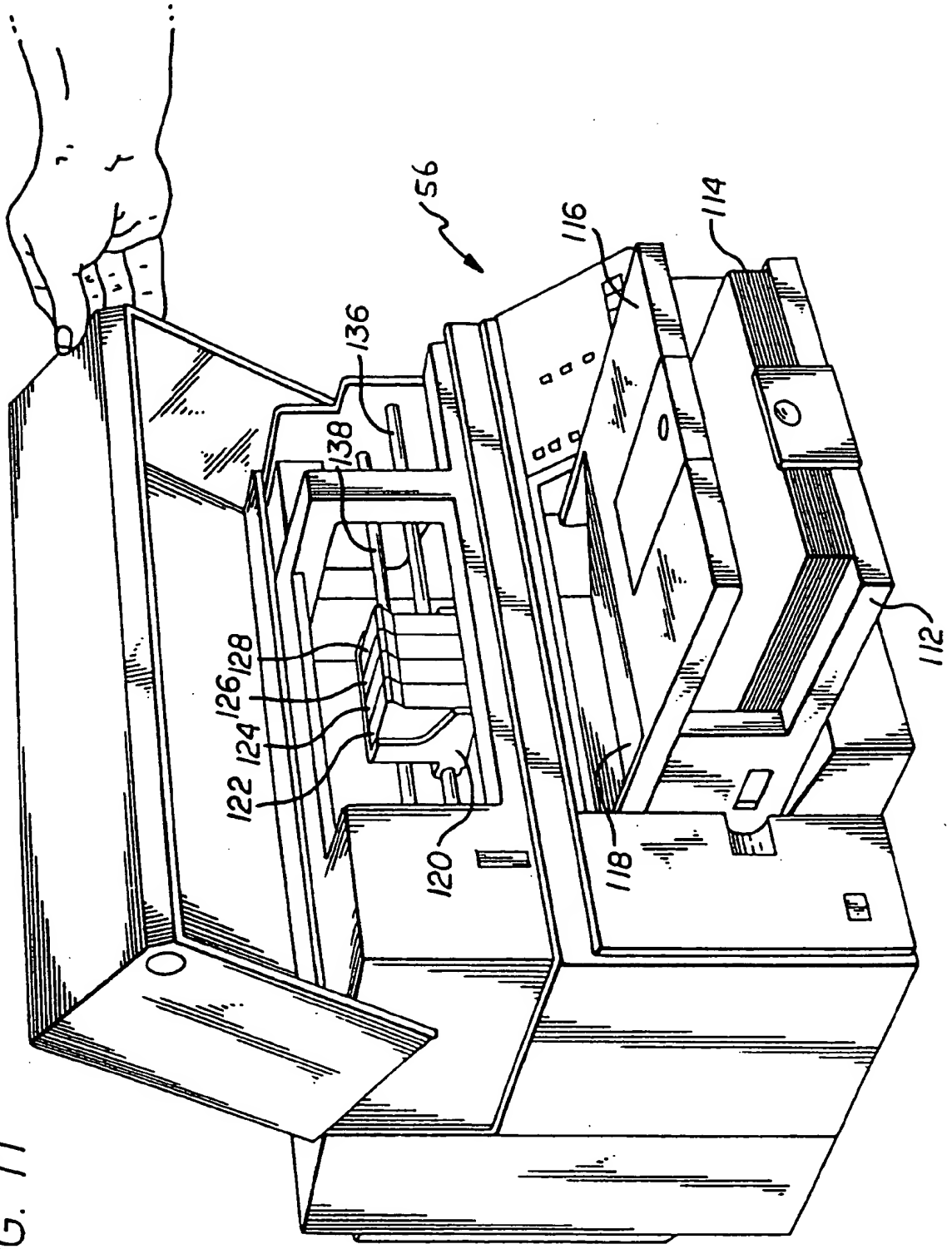


FIG. 11

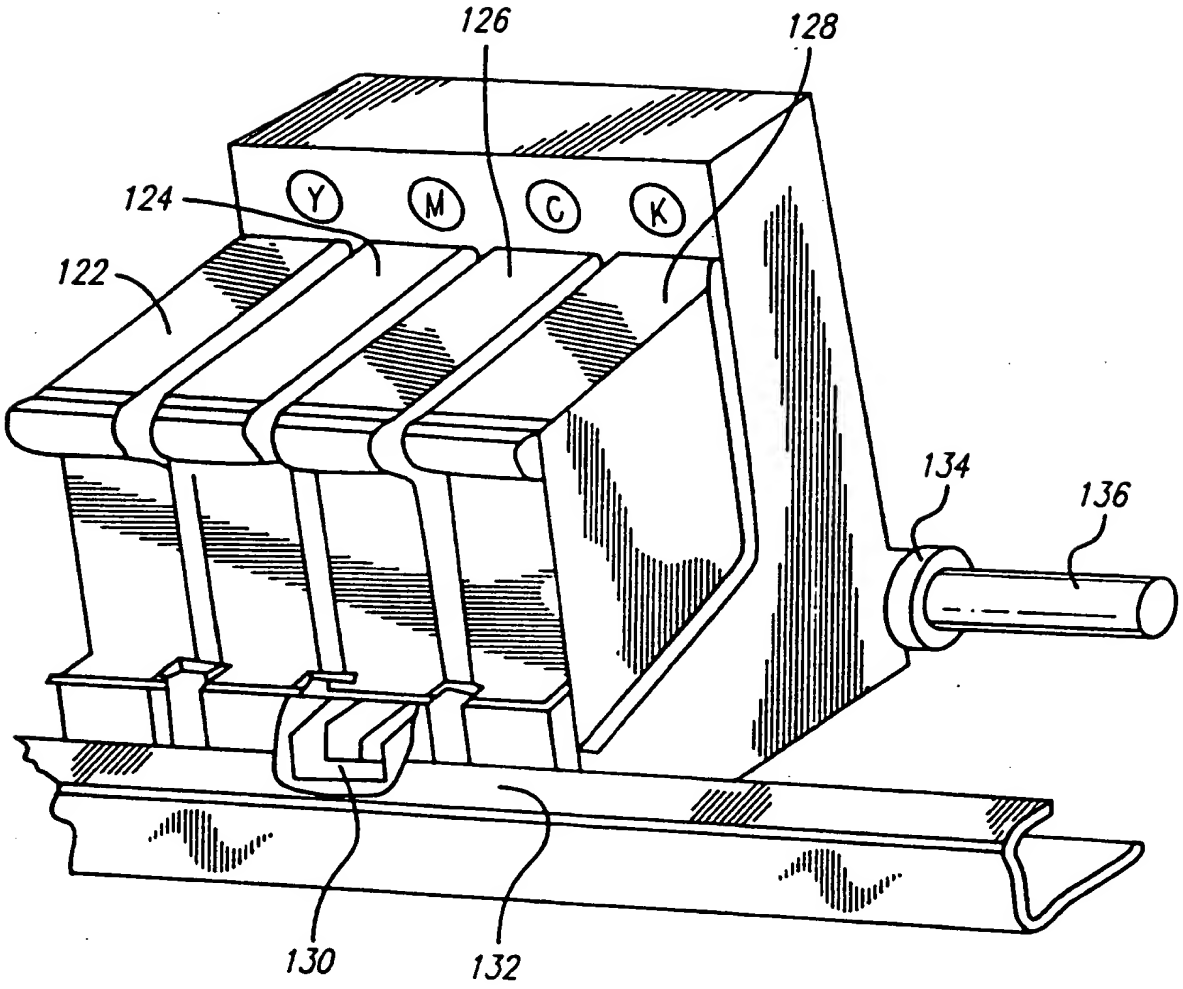


FIG. 12